Converting 6inch Asphalt to a Soil Depth

The basic shielding calculation is:

$$I_f = I_0 e^{-\mu_L t}$$

Where I_f is the final intensity of radiation,
I_0 is the original intensity of radiation
μ_L is the linear attenuation coefficient of the material attenuating the radiation, and
t is the thickness of the attenuator

If we divide by I_0, we get the fraction of intensity that has been attenuated when passing through a specific absorber of a specific thickness (t).

$$\frac{I_f}{I_0} = e^{-\mu_L t}$$

If we use soil, the fraction of intensity equation would look like the following:

$$\frac{I_{f,soil}}{I_{0,soil}} = e^{-\mu_{L,soil} t_{soil}}$$

Likewise, if we use asphalt, the fraction of intensity equation would look like the following:

$$\frac{I_{f,asphalt}}{I_{0,asphalt}} = e^{-\mu_{L,asphalt} t_{asphalt}}$$

For Hunter's Point, we want to determine how much soil would give us the same fraction of intensity as 6inches of asphalt. To determine the depth of soil needed, we will set both the fraction of intensity of soil and asphalt equal to each other as followed:

$$e^{-\mu_{L,soil} t_{soil}} = \frac{I_{f,soil}}{I_{0,soil}} = \frac{I_{f,asphalt}}{I_{0,asphalt}} = e^{-\mu_{L,asphalt} t_{asphalt}}$$

If we cancel out the intensity fraction, this would give us:

$$e^{\mu_{L,soil} t_{soil}} = e^{\mu_{L,asphalt} t_{asphalt}}$$

To eliminate the exponential, we multiply each side by natural log of each side.

$$ln(e^{\mu_{L,soil}t_{soil}}) = ln(e^{\mu_{L,asphalt}t_{asphalt}})$$

This would give us:

$$\mu_{L,soil}t_{soil} = \mu_{L,asphalt}t_{asphalt}$$

If we solve to t_{soil}, this would give us the equation needed to determine the depth of soil needed to equal 6 inches of asphalt.

$$t_{soil} = \frac{\mu_{L,asphalt}t_{asphalt}}{\mu_{L,soil}}$$

In order to solve the above equation, we must know the linear attenuation coefficient for soil and asphalt. The linear attenuation coefficient is determined by specific energies. If we look at a lower energy such as 0.186MeV for Ra-226, we get the following

$$t_{soil} = \frac{\mu_{L,asphalt}t_{asphalt}}{\mu_{L,soil}}$$

where the $t_{asphalt}$=6 inches = 15.24 cm
$\mu_{L,asphalt}$ = 0.307 cm^{-1}
$\mu_{L,soil}$ = 0.195 cm^{-1}

$$t_{soil} = \frac{0.307\ cm^{-1} \times 15.24\ cm}{0.195\ cm^{-1}}$$

$$t_{soil} = 23.99$$

If we look at a higher energy such as 2.614MeV for Tl-208, we get the following:

$$t_{soil} = \frac{0.0916 cm^{-1} \times 15.24 cm}{0.0541\ cm^{-1}}$$

$$t_{soil} = 25.79$$